*Indian J. Phys.* **73B** (5), 695-699 (1999)

**IJP B**
an international journal

# Studies on some aspects of solar X-ray flares

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*Received 13 April 1998, accepted 4 June 1999*

**Abstract** : Studies have been made on the Solar X-ray flares observed by GOES during the period July, 1993 – June, 1994, which encompasses the post-maximum phase of 22nd solar cycle It has been examined that N-S asymmetry remains positive in respect of both latitudinal position and intensity of X-ray flares and increases with the increase of intensity The E-W asymmetry is found to be zero, when longitudinal distribution is considered , but it remains positive upto a certain intensity value above which it becomes negative The duration and rise time lie respectively in the ranges of values 5-15 min and 0-5 min. The distribution of impulsiveness of X-ray flares follows almost Binomial distribution pattern peaking around 0 45

**Keywords** : Sun, X-ray flares

**PACS No.** : 96 60 Rd

## 1. Introduction

In our earlier paper [1], a study on the solar X-ray bursts observed in the wavelength bands 0.5 – 4 Å and 1-8 Å was made in relation to the associated *H*-alpha flares. But, recently Solar X-ray flares are being observed by several X-ray missions, such as, YOKOH, SOHO, GOES *etc* which are storing voluminous amount of data. Again, the X-ray signature of flares may give as good, or better, criteria for classification purposes of solar flares, so that we can deal with better coverage and rely on quantitative, more objective data. Moreover, a more profound physical insight into the flare phenomenon can be achieved with the help of the X-ray criteria. Hence, in the present paper, some studies on the X-ray flares have been made in order to elucidate a few important aspects of flares depending on the measured parameters like X-ray flux, duration, heliographic position on the visible disc *etc*. In this connection it is to be mentioned that the energy flux could not be directly measured for *H*-alpha flares which were observed in the visible part of the spectrum. In addition, smaller flares, referred to as subflares, which were ignored in all the flare classifications prior to the 1960s can now be accommodated with the help of classification based on X-ray criteria [2].

## 2. Method of analysis

Solar X-ray flare data were collected from the Solar Geophysical Data Bulletins [3] published by U.S. Department of Commerce, Boulder, Colorado. These X-ray flares were observed by GOES in which payloads have been incorporated in order to measure the soft X-ray intensity and other related data. The observations were made during the period from July, 1993 to June, 1994 which covers a part of the post maximum phase of the 22nd solar cycle. Although X-ray data on 1932 flares were available for the present analyses, positional data like latitude and longitude of the flare on the solar disc and the intensity and duration of the flare have not been reported simultaneously. Hence, the number of data has, reduced in size in some of the cases in the present study.

## 3. Results

The results obtained from the present analyses are enumerated in the following :

*North south asymmetry :*

The latitude distribution of solar X-ray flares as shown in Figure 1(a) reveals that all the events are confined within the latitude range 30° S-20°N. About 60% of the events are found to spread over a latitude 0 ± 10°. The N-S asymmetry is highly positive, and hence, the northern dominance in the occurrences of X-ray flares is inferred from this study.

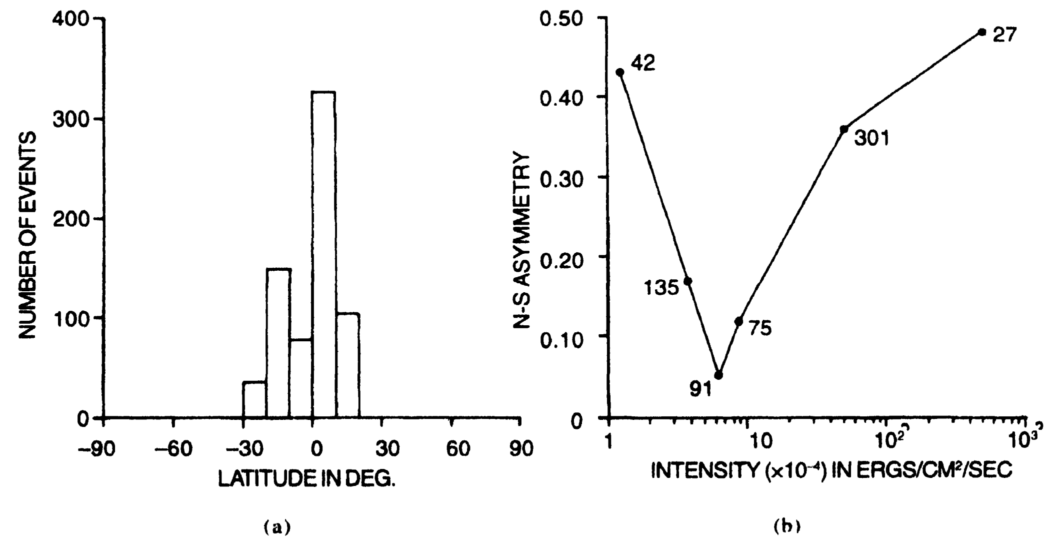


**Figure 1.** (a) Histograms showing the distribution of X-ray flares in different ranges of latitudes and (b) N-S asymmetry plotted against the intensity of X-ray flares, the numerical figures indicate the number of events over which the asymmetry has been calculated.

In the next phase this study is extended to examine the intensity dependence of *N–S* asymmetry of X-ray flares. Now, N-S asymmetry = $\frac{N-S}{N+S}$ , where $N$ and $S$ represent the number of events in the Northern and Southern hemispheres respectively. It is observed from Figure 1(b) that N–S asymmetry decreases with the increase of intensity and attains a minimum value around $6 \times 10^{-4}$ ergs/cm$^2$/sec, above which it increases with the increase of intensity (Figure 1b). Moreover, N–S asymmetry remains positive for all values of intensity, indicating the northern dominance of flares. It has been found that about 60% of the events fall in the high intensity group (above $10^{-3}$ ergs/cm$^2$/sec) which exhibit strong asymmetry, giving a clear predominance of these events in the northern part of the solar hemisphere during post-maximum phases of cycle 22.

*East-west asymmetry :*

The longitude distribution of X-ray flares as shown in Figure 2(a) suggests that most of the events occurred within the ranges of longitude $0 \pm 50°$ and there is no clear predominance of the events in any of the hemispheres (eastern or western) in repsect of their occurrences, giving almost zero E-W asymmetry. Moreover, an even distribution of events is observed all over the disc. This holds good for both the eastern and western hemispheres of the Sun. The decrease of number of events at high longitudes could be due to selection effect associated with the difficulty arising in detection of events.

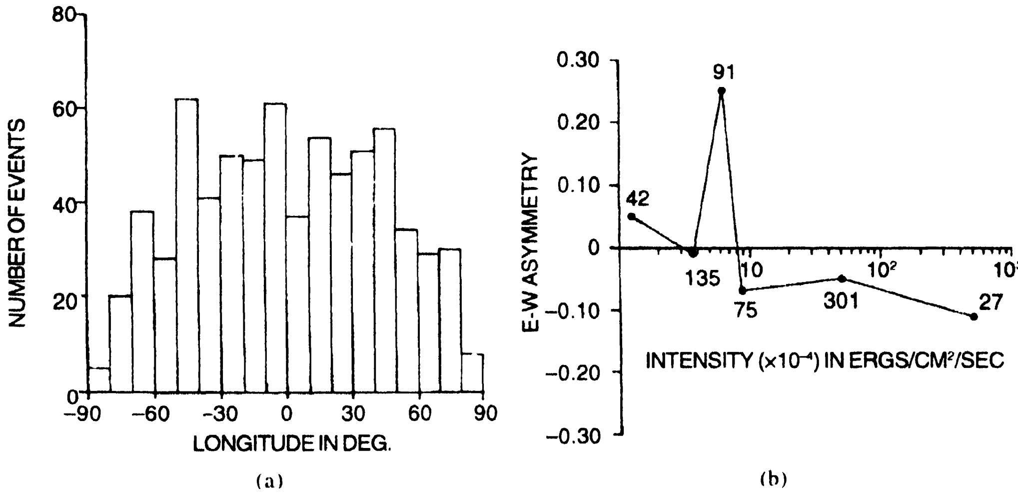


**Figure 2.** (a) Histograms giving the distribution of the events over the longitudes on the disc, and (b) E-W asymmetry plotted against the intensity of X-ray flares

Next the E-W asymmetry was studies in respect of the intensity of the X-ray flares, the E-W asymetry is defined as :

$$\text{E-W asymmetry} = \frac{E-W}{E+W},$$

where $E$ and $W$ represent the number of events in the Eastern and Western hemispheres respectively. It is observed that this sort of asymmetry is mostly positive upto the intensity value of $8 \times 10^{-4}$ ergs/cm$^2$/sec and it becomes negative above this limiting value. About 60% of the events which have intensity values greater than this limiting value show western dominance, giving rise to the negative value of the asymmetry.

*Duration of X-ray flares :*

The frequency distribution of the duration of X-ray flares has been shown in Figure 3(a). About 60% of the events have been found to possess durations in the range 5-15 min.

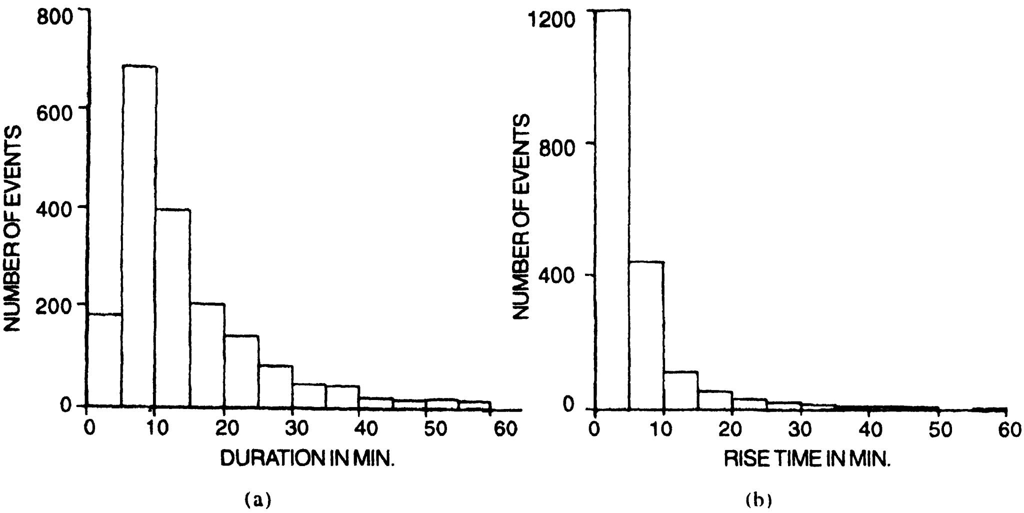


**Figure 3.** (a) Distribution of the events in different ranges of duration of X-ray flares and (b) distribution of the events in different ranges of rise time

*Rise time of X-ray flares :*

The rise time giving the time interval between the starting time and the time of attaining the maximum phase of X-ray emission has been determined in each of the X-ray flares under consideration. Figure 3(b) shows the occurrences of these events in different ranges of rise time. It is observed that more than 60% of the events have rise times between 0 – 5 min.

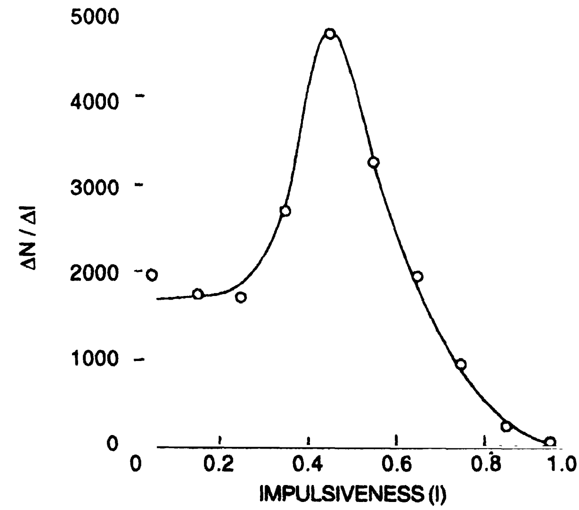


**Figure 4.** Number of events per unit interval of impulsiveness $\left(\frac{\Delta N}{\Delta I}\right)$ plotted against the mid values of the adopted ranges of impulsiveness (I).

*Impulsiveness of X-ray flares :*

We have defined an impulsiveness (I) parameter as :

$$I = \frac{\text{Rise time}}{\text{Duration}}$$

such that the smaller the value of $I$, the greater is the impulsiveness of the particular event. The values of $I$ found out for each of the events are grouped in several convenient ranges and the number of events in each of these ranges has been found out from which the ratio $\frac{\Delta N}{\Delta I}$ has been calculated. The values of $\frac{\Delta N}{\Delta I}$ have been plotted against the mid values of the adopted ranges of $I$ as shown in Figure 4. The curve resembles that of the Binomial distribution, which clearly signifies that the probability of the events having impulsiveness in the vicinity of 0.45 is largest, while it becomes smaller both for the lower and higher values of impulsiveness. As 65% of the total data have the impulsiveness value 0.45, we may infer that most of X-ray flares are highly impulsive in nature.

## 4. Discussion

From the foregoing analyses, it appears that the X-ray flares predominate in the northern hemisphere when the variation of N-S asymmetry with the latitudinal position and the intensity of flares is examined. Most of the authors[4-6] who made studies on other types of solar activity, such as, sunspots, flares, faculae, prominences, coronal holes and radio bursts at different phases of 19th and 20th solar cycles, reported a northern excess of these kinds of solar events. It is also interesting to note that X-ray flares which exhibit northern excess are very intense in nature. When the E-W asymmetry is examined, it is found that no clear preference is observed, in agreement with earlier reports. But the asymmetry found out in respect of the X-ray intensity, shows western dominance for the flares of higher intensity values. The Binomial distribution nature of the impulsiveness of X-ray flares clearly indicates that most of the flares are highly impulsive in character.

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